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SEALS AND FISHERIES IN SOUTH AFRICA — COMPETITION AND CONFLICT

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There are two types of interactions between seals and commercial fisheries in South Africa: biological (potential competition for shared resources between the two "predators") and operational (conflicts during fishing operations). Using data for the 1980s, a comparison is made of relative consumption by different predators in South African waters. Seals and fisheries are not the major consumers in the system, but they do take comparable amounts. This has resulted in calls for a reduction in the seal population, but to date, no studies have shown that reducing seal predation of commercial species will make more fish available for the fisheries. Most fisheries are subject to some form of operational interaction with seals. These interactions include consumption of catches (operational consumption), disturbance of fishing operations (operational disturbance) and damage to fishing gear (operational gear damage); they vary in degree of severity, both seasonally and regionally. Estimates of the consumption by seals from fishing operations in South Africa show it to be a minimal percentage of fishery catches and a small proportion of the total predation by seals. Preliminary calculations of overall economic losses resulting from seal interference show this to be small in comparison with the wholesale value of the catches. Seals die as a result of fishing operations, and estimates of the potential mortality through entanglement, drowning and deliberate killing indicate this mortality to be of a magnitude that should be monitored.

Daar is twee soorte wisselwerking tussen robbe en handelsvisserye in Suid-Afrika: biologies (pòtensiële mededinging om gedeelde hulpbronne tussen die twee "predatore") en operasioneel (botsings tydens visvangsbedrywighede). Met gebruikmaking van gegewens vir die 1980s word 'n vergelyking getref tussen relatiewe verbruik deur verskillende predatore in Suid-Afrikaanse waters. Robbe en visserye is nie die hoofverbruikers in die stelsel nie, maar hul verbruik wel vergelykbare hoeveelhede. Dit het vertoë tot gevolg gehad vir 'n uitdunning van die robbebevolking, maar tot nou toe het geen studies aangetoon dat vermindering van die robbe se rooftogte op ontginde spesies meer vis aan die visserye beskikbaar sal stel nie. Die meeste visserye is onderhewig aan die een of ander operasionele wisselwerking met robbe. Dit sluit verbruik van vangste (operasionele verbruik), versteuring van visvangbedrywighede (operasionele versteuring) en skade aan visvangtuig (operasionele tuigskade) in; hulle wissel in hewigheidsgraad, sowel seisoens- as streeksgewys. Ramings van robbe se verbruik by visvangbedrywighede in Suid-Afrika toon dat dit 'n minimale persentasie van die visserye se vangs uitmaak en maar 'n klein gedeelte van die totale plunder deur robbe. Voorlopige berekenings van die algehele ekonomiese verlies as gevolg van die inmenging deur robbe toon dat dit klein in vergelyking met die groothandelwaarde van die vangste is. Robbe sterf as gevolg van visvangbedrywinghede, en ramings van eventuele mortaliteit weens verstrengeling, verdrinking en doelbewuste doodmaak dui daarop dat dit ernstig genoeg is om monitering te regverdig.

There are two types of interactions between seals and fisheries in southern Africa: biological (potential competition for a common resource between the two "predators") and operational (conflicts during fishing operations). From a fisheries point of view, operational conflicts occur when seals take fish directly from fishing operations (for which concerns are that catches are lost and that the industry is supporting an artificially high seal population), disturb some fishing operations or damage equipment. From the seals' point of view, operational interactions include mortality or injury from being shot or maimed by fishermen, entanglement in discarded fishing gear and drowning in nets.

The South African fur seal *Arctocephalus pusillus pusillus* breeds and feeds on the Namibian coast and on the South African west and south coasts (Fig. 1), all areas that sustain profitable fishing industries. Since the first major census in 1972, the total seal population has expanded and, in particular, numbers at the major colony of Kleinsee in South Africa have increased (Wickens *et al.* 1991). Currently, the population is estimated at no more than 2 million seals (Butterworth and Wickens 1990, Butterworth and Harwood 1991), of which approximately 1,7 million feed at sea (ac-

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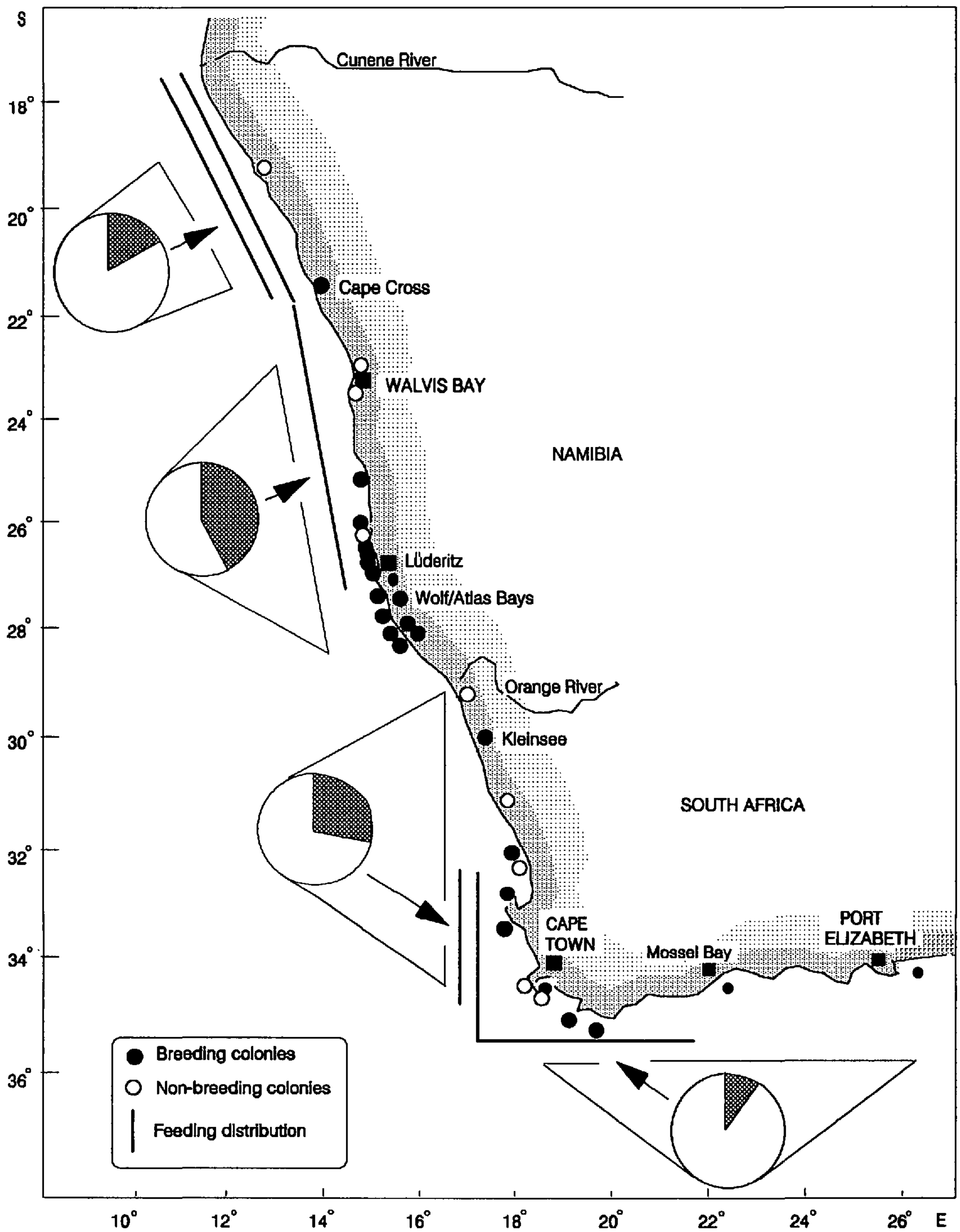

Fig. 1: Distribution of breeding and non-breeding colonies, abundance of seals (indicated by the shaded area in the pie diagrams for different regions, based on 1989 pup-production figures, Wickens *et al.* 1991), and the feeding distribution (W. H. Oosthuizen, Sea Fisheries Research Institute, pers. comm.) of the South African fur seal. The difference between the breeding and feeding distributions is apparent

counting for 0,3 million pups that suckle for most of their first year). Of the total, an estimated 0,6 million seals feed in South African waters (based on the distribution of pup production between Namibia and South Africa — Wickens *et al.* op. cit.). This has caused concern that fisheries catches may decline as a result of the increased predation by seals, and it has resulted in calls for culling of seals to reduce the seal population in order to lessen operational interferences and make more fish available for harvesting.

Antagonism at the interactions between seals and fisheries off southern Africa is not new. As far back as 1901, fishermen petitioned the government to reduce the number of seals on Seal Island, Mossel Bay, because catches had declined (Anon. 1901). There are also reports from the 1930s of fishermen on expeditions to kill seals because "the fishermen's livelihood was being taken away from them by the seals" (extract from *Cape Argus* of 22 October 1930, reprinted in Crawford and Payne 1989). Studies and discussions of seal/fisheries interactions have been undertaken both locally (Rand 1959, Shaughnessy *et al.* 1981, Shaughnessy 1985, Anon. 1987, 1990b, David 1987, Butterworth *et al.* 1988, Wickens 1989) and worldwide (e.g. Bonner 1982, Northridge 1984, 1986, Beddington *et al.* 1985, Royal Commission on Seals and Sealing in Canada 1986, Gulland 1987, Harwood and Croxall 1988), and the problems encountered are similar. Northridge (1984) reviewed interactions between marine mammals and fisheries and showed that only the interactions of four species of seal can be regarded as being of particular significance to either the seal population or to a fishery, in terms of both biological and operational interactions. The species are grey seals *Halichoerus grypus* in the North-West Atlantic, harp seals *Phoca groenlandica* in the North Atlantic, northern fur seals *Callorhinus ursinus* in the North-East Pacific and the South African fur seal in the South-East Atlantic.

Seal-related problems are both complicated and fraught with arguments based on emotions, therefore often making them the subject of heated debate. For example, two reports, one by the Royal Commission on Seals and Sealing in Canada (1986) and the other by the South African Diemont Commission (Diemont 1986), in which sealing is discussed, have been criticized by Holt (1987) and Butterworth *et al.* (1988) respectively as having treated the issues inadequately and incorrectly. In 1990, pressure from animal rights groups in South Africa caused a halt to sealing while all aspects of sealing in South Africa were reviewed by a government-appointed committee (Anon. 1990b). The government's decision was to suspend all commercial sealing in South Africa for two years while further scientific research, including that of seal/fisheries interactions, was carried out (Pienaar 1991).

The aim of this paper is to provide an overview of both biological and operational interactions between seals and commercial fisheries in South Africa in order to place them in perspective. As regards the biological interactions, consumption by seals is viewed in context with other competing predators in the system. For the operational interactions, all local literature is reviewed, the conflicts are described, and preliminary calculations are made to evaluate the impact seals have on fisheries, and *vice versa*. Although not examined in this paper, the problems encountered in Namibia are most likely similar, although possibly more extensive because of the larger population of seals there. In addition to the operational interactions that occur with commercial fisheries, recreational fisheries also experience interactions with seals, but these are beyond the scope of this paper.

BIOLOGICAL INTERACTIONS

As seals are believed to impact on commercial fish stocks, it is necessary to evaluate seal consumption, to compare it with that of other top predators and to consider whether reducing the seal population is a realistic solution to improving fishery yields.

Consumption by seals

In 1950, when little quantitative information was available for seal predation, Neale-May (1950) calculated that seals in southern Africa were eating 3,5 million tons of food per year. However, the current estimate of annual consumption by the entire South African fur seal population, which is much larger than it was in 1950, is placed at no more than 2 million tons per year (Butterworth and Wickens 1990, Butterworth and Harwood 1991), of which less than 0,8 million tons is consumed in South African waters (based on the distribution of pup production — Wickens *et al.* 1991).

Over the 40-year period 1950–1990, research to evaluate seal predation in southern Africa has expanded enormously. Estimates of consumption rate, which is directly related to body mass, have varied over the years such that the estimated average daily ration of seals has diminished overall from 18,2–22,7 kg (Neale-May 1950), through 2,3–6,8 kg (Rand 1959), 100 kg (Diemont 1986), 4,8 kg (David 1987) and 1,4–6,4 kg (depending on age and sex, Wickens *et al.* 1992) to 3,2 kg (calculated from Butterworth and Wickens 1990 and Butterworth and Harwood 1991). The last value is thought to fall in the upper range of acceptable consumption rates for the species (Butterworth and Harwood op. cit.).

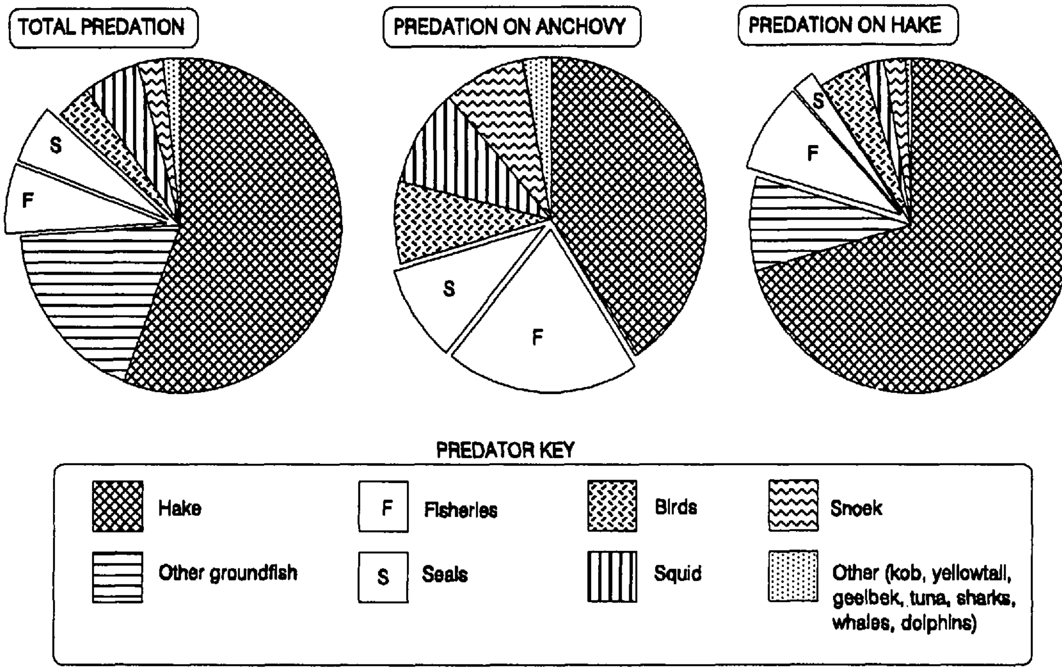

Fig. 2: Comparison of total consumption by different predators, including commercial fisheries, in South African waters, and consumption of the important commercial species, anchovy and hake, by these predators (data from Field *et al.* in prep.)

Seal diet has been documented by Rand (1959) for the 1950s and by David (1987) and Lipiński and David (1990) for the 1970s and 1980s. The South African fur seal is generally considered an opportunistic feeder, changing diet spatially and temporally in response to the availability of its prey items.

Comparison of consumption by top predators

Comparisons are made between the average consumption of prey for the 10-year period between 1980 and 1989 by seals and other predators, for which the data are considered to be reasonably well known (data from Field *et al.* in prep.) — Fig. 2. Of piscivorous predators in the ecosystem, the two species of Cape hake *Merluccius capensis* and *M. paradoxus*, which are cannibalistic, are by far the largest consumers (56%), followed by all other groundfish combined (18%) and fisheries (7%). Seals consume only 6 per cent of the total consumption of fish, indicating that seals and fisheries take comparable quantities from the system.

Seals play an important role in the predation of the key pelagic resource, anchovy *Engraulis capensis*, but take half (10%) the quantity taken by the fishery (20%). Hake are the major predators of anchovy, taking double that of the fishery (40%). In terms of the main demersal resource (hake), seals (taking 2% of all hake predation) are not major predators, taking far less than the fisheries (9%) and many other predators.

Evaluating the control of seals to improve fishery catches

The assumption that reducing the seal population will make more fish available for the industry is simplistic when applied to a complex ecosystem. Seals prey on at least 28 species (David 1987) and there are many interactions (predation, competition and cannibalism) between the prey species. Evaluation of whether fishery yields will increase if seals are culled, as well as whether any increase can be linked directly to a reduction in seal numbers, is difficult and requires appropriate data on many aspects of the problem. One needs to define the system, i.e. the fish species involved, and the nature and strength of interactions between fish species and between seals and fish. Information is then required on, for example, the relative ages of fish taken by each predator, the magnitude of seal predation relative to the other rates of natural and fishing mortalities, and variability in the magnitude of the different mortalities as the mortality attributable to seals changes (because there are always many intrinsic changes and compensatory effects in a population in response to changes in the system). Because of the interactions between species, not all fisheries would necessarily benefit from a decrease in seal population size; instead, a trade-off between different sectors of the fishing industry could be anticipated.

As with other studies of seal/fisheries interactions worldwide, previous local evaluations of culling as a solution to biological interactions (Shaughnessy 1985, Butterworth *et al.* 1988, Wickens and Shelton 1988, Wickens 1989, Anon. 1990b, 1991) have proved neither conclusive nor prescriptive. Nevertheless, it may be possible in future to provide a qualitative indication of the effect of a seal cull on fishery yields. However, there remains the difficulty of detecting the effect because of considerable natural fluctuations in fish stocks (Butterworth and Harwood 1991).

OPERATIONAL INTERACTIONS

Interactions detrimental to fisheries

As a result of antagonism towards seals by fishermen because of interference during fishing operations, operational interactions are an emotive issue, and biases are complex and difficult to quantify. Evaluations of these interactions have proved incomplete (Rand 1959, Shaughnessy 1985, David 1987, Anon. 1987, 1990b, Wickens 1989). The current evaluation is confined to fisheries operating off the South African coastline and is based on figures for 1989. In this evaluation, the main problem regions and seasons are highlighted for each fishery and a full description and preliminary quantification of the magnitude of the impact seals have on fisheries is given in terms of:

- "operational consumption" — consumption by seals of (i) fish in the catch or (ii) fish discarded during fishing operations, either whole (e.g. undersize fish) or parts thereof (e.g. heads, guts);
- "operational gear damage" — direct loss or damage of fishing gear resulting from seals;
- "operational disturbance" — disturbance of operations in which the mere presence of the seals causes catches to be reduced and time wasted, e.g. dispersal of shoals, time taken to repair operational gear damage.

Information was gathered from discussions with researchers associated with the different fisheries and members of the fishing industry. It must be emphasized that these estimates provide the average impact through one year, although the impact of specific incidents may be substantially greater.

The South African coastline has been divided for the purpose of this paper into three areas to coincide roughly with the distribution of feeding seals. Area 1 ranges from the Orange River (28°30'S) to Lambert's Bay (32°S), Area 2 from Lambert's Bay to due south of Cape Point (18°30'E) and Area 3 from Cape Point to Port Elizabeth (25°30'E). Many seals feed in Area 2 (see Fig. 1) and most of the fishing effort occurs in this area (Fig. 3). As the distribution of seals on breeding grounds differs from that when they are feeding (see Fig. 1), calculations are not done by area, but for the total seal population in South African waters.

Different methods of calculating operational consumption are adopted for the different fisheries. Equations 1 and 2 below apply to calculation of operational consumption from the two major net fisheries, the trawl and purse-seine fisheries. These fisheries have a quota as opposed to a season restriction and are assumed to be able to fish for a longer time-period to replace the losses to seals. If quotas are filled, the total annual catch therefore remains the same, but it may take longer to catch it. The assumption is made that the numbers of seals observed at a single haul each consume their daily ration of fish (3,2 kg, see earlier). Seals may take fish from the net, so-called "stickers" (fish protruding through the net mesh), or fish floating free of the net. This approach was followed by David (1987), using earlier estimates for consumption rate and observed numbers of seals. Although the assumption of seals consuming their daily ration at a haul is, as stated by David (op. cit.), "an admittedly tenuous assumption", it can be used as a starting point. It must be remembered that one boat may make a few hauls during one day, attended possibly by the same seals, and the same group of seals may also move between fishing boats, taking fish from different hauls. Therefore, seals can consume more than this daily ration during a day's feeding at hauls. Seals also "play" with fish, and this is assumed to be included in the calculation of operational consumption. Annual operational consumption (E) is estimated from the number of hauls made during the year (H) multiplied by the average number of seals seen at a net (S), and multiplied by the daily ration of one seal. The percentage of the catch lost to seals (pE_{catch}) is estimated as the quantity eaten (E) divided by the catch (C). In other words,

$$E = H \times S \times 3{,}2 \text{ kg} \quad , \qquad (1)$$

$$pE_{catch} = E/C \times 100 \quad . \qquad (2)$$

Equation 3 applies to the calculation of operational consumption from the longline and handline fisheries and miscellaneous net fisheries (e.g. beach-seining,

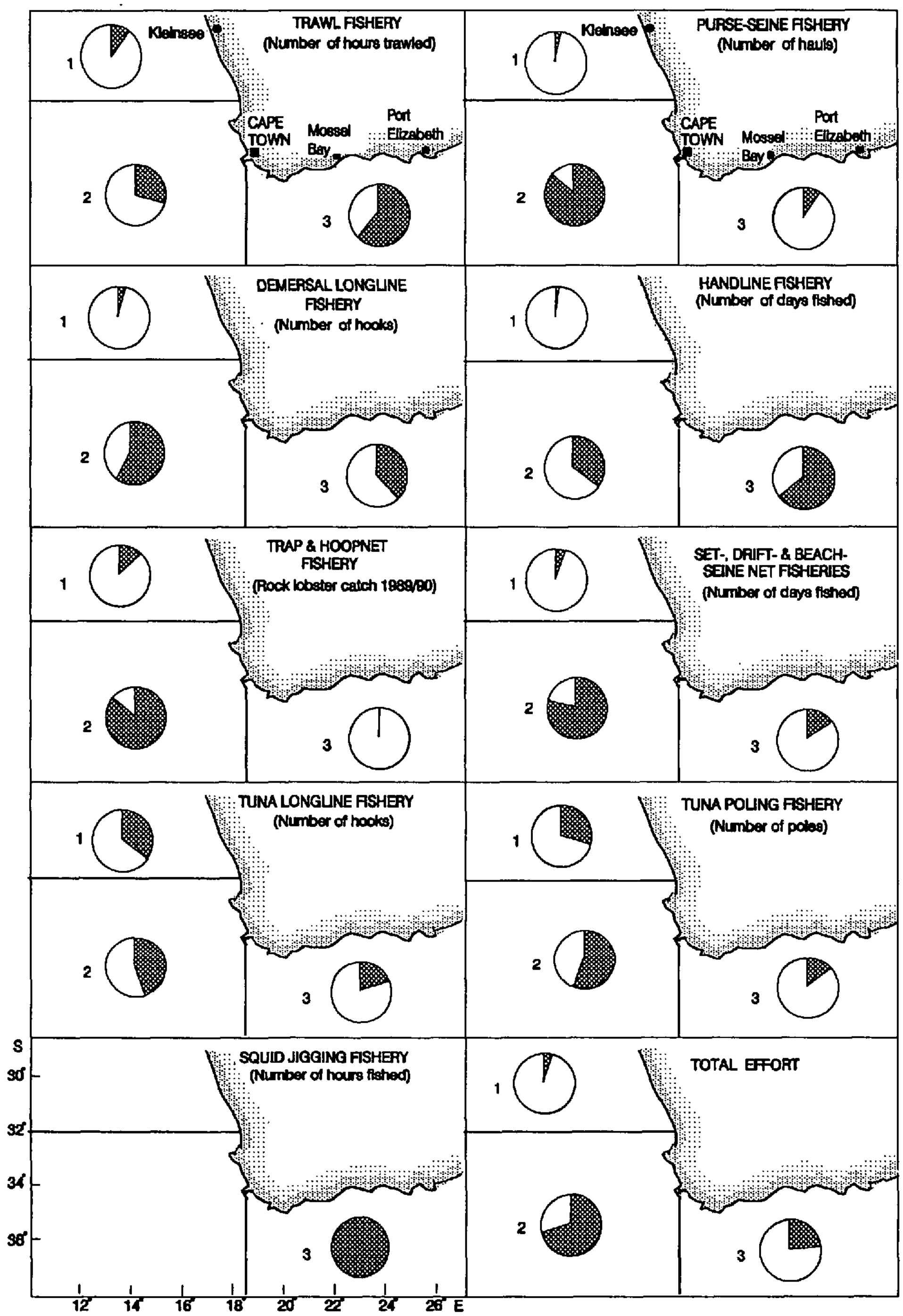

Fig. 3: Distribution of commercial fishing effort in 1989 (indicated by the shaded area in the pie diagrams as proportions of the total), in each of the three designated areas of the southern African coastline (see text) for each fishery, and total effort, calculated by weighting the distribution of effort by the catch for each fishery in each area. Effort units used are given in parentheses

set-netting). For these, information is available on the percentage of the catch lost to seals. These fisheries operate on a fishing season basis as opposed to a quota system, so losses to seals constitute real losses from the fishery. The quantity eaten from lines by seals (E) is the percentage lost (pE_{catch}) multiplied by the catch (C), which is corrected to account for the percentage lost to seals (pE_{catch}):

$$E = pE_{catch} \times C/(100 - pE_{catch}) . \quad (3)$$

A further equation is used to evaluate whether the fishing industry could be supporting the increases in the seal population through seals feeding from the operations of all fisheries. From the above information, an approximate percentage of the total consumption by the seal population (pE_{cons}) in South Africa of 0,8 million tons·year^{-1} (see earlier) that can be gained from consumption at fishing operations (E) is estimated:

$$pE_{cons} = 100 \times E/800\,000 \quad . \quad (4)$$

TRAWLING

The major fishery off South Africa in terms of value is the trawl fishery (Payne and Crawford 1989). On the West Coast, bottom trawling targets the two species of Cape hake *Merluccius capensis* and *M. paradoxus*, whereas on the South Coast, midwater trawling targets mainly Cape horse mackerel *Trachurus trachurus capensis* and inshore trawling targets Agulhas sole *Austroglossus pectoralis*, hake and horse mackerel. Trawling involves dragging a net along the sea bed or in midwater for an average of three hours, and then hauling it to the surface with its catch.

Operational consumption — Seals sometimes take fish from the catch, but loss and spoilage to fish within the net is negligible, particularly compared to that caused by other factors. On side trawlers, used mainly inshore on the South Coast, the net lies on the sea surface for some time, so seals can take more of the catch than is possible from stern trawlers, on which the net is hauled directly onto the deck of the vessel. Most consumption by seals from trawlers is of stickers, discarded fish and fish parts (Rand 1959, Shaughnessy *et al.* 1981, Shaughnessy and Chapman 1984), and fish that float free from the net. Nearly all of the discarded fish is moribund and would be lost from the resource anyway as a result of damage from the hauling operation.

Although operational consumption is not all a loss from the catch itself, it is calculated by means of Equations 1 and 2. The mean number of seals per trawl has been estimated on research trawls as between 3 and 10 (Shaughnessy and Payne 1979, Ryan and Moloney 1988), and on commercial trawls as between 4 and 6 (Shaughnessy and Payne op. cit.). An average of five seals per commercial haul is used to calculate operational consumption at the 49 738 hauls in 1989. This consumption amounts to 796 tons per year or 0,5 per cent of the catch and is a negligible percentage (0,1%) of total consumption by seals in South African waters (Table I).

Operational gear damage — Occasionally, seals tear out a few meshes from the codend of the net, resulting in the net needing repair, but the cost of this is minimal. Also, seals sometimes cause damage to the propeller if they come into contact with it while feeding at the outlet which releases discarded fish into the sea, and this can be costly. In the case of controllable-pitch propellers, damage can cost almost R100 000. Further, fuel consumption for a trawler with a damaged propeller increases by approximately 10 per cent, requires inspection by a diver and necessitates repair or replacement. Recently, repair of propeller blades on an Irvin and Johnson trawler damaged in a seal incident cost R58 000. On average the cost is estimated at R14 000 per incident, with an estimated 22 occurrences per year, or R308 000 per annum (Deep-Sea Trawling Association unpublished data). In 1991, two Irvin and Johnson vessels underwent redesign of the factory deck layout to move the outlet for discarded fish away from the propeller, largely to minimize propeller damage caused by seals. The cost was a million rand each.

Operational disturbance — Fishing time is sometimes wasted because of seals. Live seals are regularly hauled aboard in the net and are difficult to handle and return to the sea. They can also become trapped in the factory deck (Shaughnessy and Payne 1979), where they may disrupt operations until they are removed. Crewmen are sometimes injured by bites, thereby incurring medical expenses. A rough evaluation of the cost in time lost is estimated by assuming that each incident takes an hour, running costs are R1 300 per hour and that there are approximately five such incidents per vessel per year (data from Deep-Sea Trawling Association). For the fleet of 110 active offshore, inshore and midwater trawlers in South Africa, the estimated cost in terms of time lost is therefore R715 000 per annum.

Problem area and season — The problem occurs year round in Area 2 and the western region of Area 3, particularly in deep, offshore waters on the West Coast, where seals are attracted to trawlers and their distribution is correlated with trawler activity (Ryan and Moloney 1988). There are also problems in the eastern region of Area 3.

Table I: Summary of catches and operational consumption from important commercial fisheries in South Africa based on 1989 information. Operational consumption is calculated using either observed seal numbers at the net [2] (Equations 1 and 2), or the percentage taken by seals from the catch [3] (Equation 3). Operational consumption is also presented as a percentage of catches and of total seal consumption of 0,8 million tons (see text) in South Africa

Fishery	Catch[1] (tons)	Operational consumption (tons·year^{-1})	Operational consumption/catch[3] (%)	Operational consumption/total consumption (%)
Trawl[2]	161 454	796[4]	0,5	0,1
Purse-seine[2]	408 136	759[5]	0,2	0,1
Demersal longline[3]	3 224	180	5,3	0,02
Handline[3]	12 474	294	2,3	0,04
Rock-lobster trap	3 202[6]	...	...	...
Rock-lobster hoopnet	800[6]	...	...	...
Tuna longline	2 706	...	...	...
Tuna poling	3 746	–	–	–
Squid jigging	9 792	...	...	...
Miscellaneous net[3]	2 069	21	1,0	0,003
Total	607 603	2 050	0,3	0,3

[1] Data from Economic Division, Chief Directorate of Sea Fisheries, South Africa
[4] Assuming an average of five seals at each of the 49 738 trawls
[5] Assuming an average of 20 seals at each of the 11 864 purse-seine hauls
[6] 1988/89 season for rock lobster, excluding South Coast rock lobster *Palinurus gilchristi* caught by longline traps
– No loss
... Negligible loss

PURSE-SEINING

The major pelagic fishery, in which anchovy *Engraulis capensis* is the main target species, is purse-seining. A net is set around a shoal, then pursed and, with the bag of the net still in the water, the fish are pumped aboard.

Operational consumption — Seals move into the net to start feeding before the net is pursed and continue to do so until all fish are pumped aboard. The quantity of fish consumed has not been thought of as a problem by fishermen (Shaughnessy *et al.* 1981, Anon. 1987), but it is nevertheless evaluated using the number of purse-seine hauls in 1989 and an estimate of the number of seals at a haul. In Namibian waters, large counts of the number of seals at a net have been recorded during two studies. Shaughnessy *et al.* (op. cit.) present mean counts that range between 78 and 209 during different stages of the operation, and up to 500 seals during any particular part of a haul. Skippers' records between 1982 and 1985, inclusive, showed that counts were seldom less than 50 but often more than 300 (Thomas and Schülein 1988).

Counts of seals at each haul from South African skippers' records for 1989 (Sea Fisheries Research Institute unpublished data) were analysed. Occasionally, comments are made that there were "hundreds" or "thousands" of seals present, so the figures were split into two groups: counts under 100 and counts of 100 or more. Of the counts, 99,8 per cent were of under 100 seals, with a mean of 19,4 ± 16,9 seals (± 1 *SD*, n = 1 357). Counts at each haul were not always given, so only non-zero counts have been included, making the mean figure positively biased. If it is assumed that the maximum number of seals at a net seen in Namibian waters (500, Shaughnessy *et al.* 1981) were present on average for 0,2 per cent of the time for which the >100 seals were counted and 19,4 for the remaining 99,8 per cent of time, the average number of seals at each haul would be 20. This figure of 20 seals attending each of the 11 864 net hauls in 1989 was used in Equations 1 and 2 to calculate the consumption by seals directly from purse-seine vessels in South African waters (759 tons, Table I). This amounts to 0,2 per cent of the catch, and a negligible percentage (0,1%) of the consumption by the seal population in South Africa.

Operational gear damage — Sometimes seals become entangled in the net and have to be cut loose once the net has been pulled on board, but overall there is thought to be negligible damage to gear resulting from seals.

Operational disturbance — Although Rand (1959) stated that there was no disturbance, Shaughnessy *et al.* (1981) documented that, at each of 23 observations of purse-seine operations, seals consumed fish and moved in and out of the net, depressing the float line and sliding over it. There appears to be disturbance of operations at most hauls, but the severity of the distur-

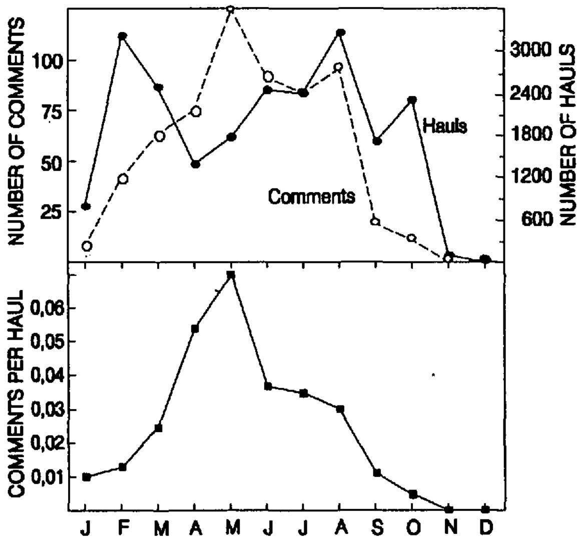

Fig. 4: Analysis of the number of comments regarding seals made by purse-seine skippers and the number of hauls (an indication of fishing effort) during each month of 1988

bance varies. The problem of seals disturbing shoals and causing the fish to sound has been described by Shaughnessy *et al.* (op. cit.), Anon. (1987) and David (1987), and it is still thought of as a problem. Other problems that have been documented are the net becoming entangled in the propeller when the fish sound, seals becoming entangled in the net and jamming in the power block as the net is hauled aboard, seals causing havoc on deck or in the fish hold, and the possibility of the fish diving into the bottom of a closed net and upsetting the stability of the boat (Shaughnessy *et al.* op. cit.).

As an indication of the type of problem encountered by purse-seine fishermen and the period when the fishermen are most frustrated by the presence of the seals, comments made by skippers during 1988 were examined (Wickens 1989). For the most part, skippers merely noted that there were many seals. More serious comments were that seals dispersed fish or caused fish to sound out of the net. They sometimes refer to the seals as "the pest" or "the plague" and have commented that all sizes of seals are involved. For each month, the number of comments was divided by the number of hauls (Sea Fisheries Research Institute unpublished data) to produce the number of comments per unit of fishing intensity. This reveals the periods of the year during which interference between seals and purse-seining operations is most severe (Fig. 4). The worst period seems to be midyear, especially during April and May, although at most there were only seven comments per 100 hauls. From November through to the beginning of the year, breeding bulls defend territories on land and feed little, and cows are colony-bound for long periods because they are pupping or suckling their young. Such seals spend less time foraging and will be feeding closer inshore, so are less likely to come into contact with the fishing boats. Fishing effort is also reduced then. By May, the pups are approximately five months old, about which time they start foraging (David and Rand 1986). As a result, the cows are able to spend more time at sea and therefore have an increased opportunity to interfere with fishing operations. There are likely to be many other factors influencing the trends in interference, but the above is speculation based on seal life history.

A perceived problem is the occasions when seal numbers are very high (250 or more), and so many seals enter the net that the chances of a successful haul are small. However, such a situation seldom happens. Taking into account that over 100 seals were counted only 0,2 per cent of the time, and that fish is not lost all this 0,2 per cent of time, it appears that loss of the entire catch happens rarely. At most it occurs once in every 500 hauls, or based on the total annual number of hauls (11 864), 24 times a year. This translates to it happening once a year to one in three skippers (of the 79 skippers operating in 1989).

Problem area and season — Interaction with the fishery is mainly in Area 2, where fishing intensity is greatest, generally between March and August.

DEMERSAL LONGLINING

Demersal longlining targeted mainly Cape hake and kingklip *Genypterus capensis* and was officially active from 1983 to 1990. Lines up to 20 km long and with 7 000–14 000 baited hooks attached at intervals of approximately 2 m were set in the early evening and allowed to "soak" overnight. Recovery of the lines was slow, occupying most of the day (Japp 1989).

Operational consumption — Seals removed fish hooked on the longlines (Anon. 1987, David 1987). Kingklip are slippery and difficult to bite and were removed from the line by biting the tail or around the gills of the fish. However, large quantities of hake were removed from the lines because the size of the fish caught is smaller and hake are less slippery and easier to bite. In the early morning, seals often removed virtually every fish on the line. Later, as the seals became satiated, they selectively removed larger fish, particularly kingklip, by tearing open the belly of the fish, taking the liver and discarding the remainder. This resulted in a proportion of the fish being lost or damaged.

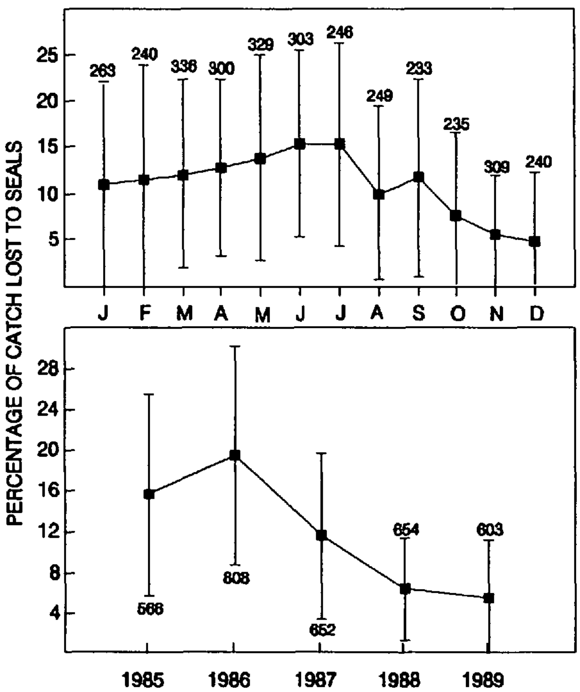

Fig. 5: Operational consumption by seals as a percentage of demersal longline catch between 1985 and 1989, as a monthly mean and an annual mean. Sample sizes are shown next to each data point

To reduce seal predation, lines were hauled faster, making it more difficult for the seals to grab fish. In addition, an inflatable boat was deployed throughout the hauling operation, thereby disrupting seal feeding behaviour and helping to keep them away from the lines. Floating fish could then also be picked up by those on the boat. However, with development of the fishery, seals adapted their behaviour by avoiding the boat, and then diving both farther away (over 200 m from vessel) and deeper, in order to remove fish from the lines. As a result, the quantities of fish removed from the line were difficult to estimate.

Skippers of longline boats guessed the percentage of the catch lost to seals and recorded this on their catch records. This was done either by watching seals taking fish or estimating the proportion of trash fish in the catch. This information was extracted from the catch records of four vessels which had the most comprehensive data sets for the period 1985–1989 (Sea Fisheries Research Institute unpublished data) — Fig. 5. Generally, skippers are thought to underestimate the percentage taken by seals (DWJ pers. obs.). The percentage lost to seals increased slightly towards the middle of the year (June/July) and then decreased again, the least amount being lost in the later months of the year (October–December). The perceived estimated percentage lost ranged between 4,6 ± 7,6 and 15,3 ± 11,1 per cent during a year.

The record of greater incidence of seal predation in the first half of the year can be explained by differences in both fishing and seal life history. On the South Coast in August, kingklip-directed longline catches peaked (Japp 1988, 1989), and fishing during that time was sustained and intense for a relatively short period, encouraging seals to aggregate in the same area. Towards the end of the year, fishing effort shifted back towards the West Coast, was less intense and generally more dispersed. Catches there were more mixed and hake-dominated (Japp 1989). It was easier to estimate the percentage of kingklip taken because large quantities of broken fish were recovered. In contrast, if whole hake were taken from the line by seals, very little of the fish was recovered. Therefore, until midyear, there was more likely to be seal interference. Later in the year, the presence of more hake in the catches made it difficult to estimate the quantity lost to seals. As explained earlier, more seals forage offshore towards the middle of the year and were able to follow boats for longer periods of time.

The trend over the years 1986–1989 indicates that the estimated percentage lost to the seals decreased from approximately 19,4 ± 10,8 per cent (±1 *SD*, n = 654) in 1986 to 5,3 ± 5,8 per cent (n = 566) in 1989 (Fig. 5). In 1983 the fishery was new, but techniques and efficiency improved each year. Kingklip longline catches peaked in 1986 and catch per unit effort then was high, whereas after 1986 the hake catch increased, making estimation of losses more difficult because fish were removed whole (Japp 1988, 1989). The overall mean percentage lost from each longline haul for the four boats per year over the five years was 11,6 ± 7,8 per cent (± 1 *SD*, n = 3 283).

For 1989, if a 5,3 per cent loss to seals is assumed, Equation 3 shows that the mass consumed by seals (180 tons) is only 0,02 per cent of the total consumption by seals in South African waters (Table I).

Operational gear damage — None.

Operational disturbance — There was no disturbance or disruption of operations except that the activity of seals necessitated having a boat in the water at all times to recover the fish discarded by seals and in an attempt at keeping seals away from the lines.

Problem area and season — The main problem areas were in Area 2 in midyear and off Cape Point (border of Areas 2 and 3) all year round when hake were being caught. The problem occurred in Area 3 in spring when longliners were targeting kingklip. The farther offshore the boats operated, the less the interference.

In the longline fishery, the effect of seal predation made it difficult to estimate catch rate accurately. In fact, the real catch rates of kingklip may have been higher than estimated. This resulted in assessment techniques and the economics of the fishery being directly affected, and it may have exacerbated the impact that longlining had on kingklip stocks.

HANDLINING

Handlining involves hand-held lines being cast from a boat, targeting mostly snoek *Thyrsites atun*, but also hottentot *Pachymetopon blochii*.

Operational consumption — Because of seals, handline fishermen lose whole fish or parts thereof, which results in these fish having to be discarded (Rand 1959, Shaughnessy *et al.* 1981). It has, in fact, been reported that snoek fishermen can lose between a quarter and a half of the fish they hook (Anon. 1990a). However, an analysis of handline losses to seals shows that 67 per cent of fishermen return to port without loss to seals, that losses vary depending on the area and species being caught, but average 2,3 per cent of all catches (Meÿer *et al.* 1992). Using that figure, the mass consumed by seals from handlines, estimated by means of Equation 3, is 294 tons or only 0,04 per cent of the total consumption by seals off the South African coast (Table I).

Operational gear damage — Seals may take or break hooks, "dollies", spinners, sinkers, swivels and lengths of handlines. Examples of loss to seals often show it to be considerable on particular occasions and of a cost that is barely covered by the fish caught (Anon. 1990a). The average value of equipment lost as a result of the activities of seals varies, depending on the species being caught and where the equipment was purchased (Meÿer *et al.* 1992). The total annual loss on the South African coastline, from the Orange River to near Cape Agulhas, in 1989 is estimated at R42 000 (Meÿer *et al.* op cit.).

Operational disturbance — Rand (1959) stated that seals frequently harassed handline fishing boats during a run of migratory fish by scattering shoals. Fishing on concentrated shoals of snoek is fast and hectic, the size of the catch being dependent on the speed with which tackle can be returned to the water. When seals are present, hooks and lengths of line are regularly lost and fishing time is then wasted while tackle is replaced. Also, the appearance of seals can disperse the shoal from under the boat and the depth of the shoal then has to be redetermined. This disturbance is extremely difficult to quantify.

Problem area and season — The problem is restricted to Area 2 during the snoek season, which is usually in winter, little interference taking place in Area 3.

ROCK-LOBSTER TRAPFISHING

One method of catching rock lobster *Jasus lalandii* involves setting individual rectangular traps in deep water (down to 150 m) and leaving them there for 10–24 hours. They are then brought on board and the catch passes through a deck grid sorter to allow undersized lobsters to escape. Another method used to catch rock lobster, but for the South Coast species *Palinurus gilchristi*, utilizes traps attached to longlines deployed in deep water, but there is no reported interference from seals.

Operational consumption — Seals seldom take rock lobster that form part of the legal-size catch, but they do occasionally consume undersized rock lobster being returned to the sea. Some of the returned rock lobster are moribund, so the effect on the resource is difficult to quantify, but it is considered negligible (Table I). The problem seems to be one of small numbers of "rogue" seals following boats.

Operational gear damage — Seals may damage bait doors on traps, but infrequently and at minimal cost.

Operational disturbance — Anon. (1987) stated that interference with traps merited further investigation. Seals may be attracted to the bait and their presence in the vicinity of the traps may disturb the rock lobster. The problem of operational disturbance is probably a fairly general one, but it is difficult to quantify.

Problem area and season — The problem occurs inshore in Area 2 during the fishing season, November–July.

ROCK-LOBSTER HOOPNETTING

Rock-lobster hoopnets are set in water shallower than 30 m and are left for approximately 30 minutes. The catch is sorted by hand and sublegal animals are returned to the sea.

Operational consumption — As for the trap-caught animals, seals seldom take rock lobster that form part of the legal-size catch. The few they do consume are undersized rock lobster being returned to the sea, but this is considered to be negligible (Table I), particularly as some of the rock lobster are moribund.

Operational gear damage — Seals are attracted to the bait and do damage or remove bait bags from hoopnets, but this is probably of minimal cost.

Operational disturbance — Rand (1959) noted that seals are only a problem when they take bait from nets. Seals take bait from hoopnets, and they disturb rock lobster that may otherwise have entered the nets. This results in time being wasted during which lobster do not approach the net.

Problem area and season — The problem occurs inshore in Areas 1 and 2 in the fishing season of November – July.

TUNA LONGLINING

Buoyed surface longlines (<20 km long) with 7 000–14 000 baited hooks attached at 2-m intervals are used to catch tuna, mainly longfin tuna (albacore) *Thunnus alalunga*. Lines are set, left overnight and recovered during most of the following day.

Operational consumption — Seals generally take only the small tuna from lines. Nepgen (1970) reported that sharks damaged 2,4 per cent of tuna caught on longlines and that seals took only the occasional tuna, so operational consumption by seals is taken to be negligible (Table I).

Operational gear damage — If large seals become hooked they may break the hook and hook-line off the main longline, but the cost of this is negligible.

Operational disturbance — Seals sometimes take bait from the lines, but this is not serious.

Problem area and season — The problem occurs during most of the year, excluding December and January, and in all areas.

POLING

Poling for tuna, again mainly longfin tuna, involves chumming (throwing either bait pieces, live bait or spraying the water to attract fish to the surface to feed). The tuna are then hooked and lifted on board.

Operational consumption — None (Table I).

Operational gear damage — None.

Operational disturbance — Seals may be attracted by the chum, which they feed on, and in doing so they disrupt the tuna, thereby reducing catchability. This effect is difficult to quantify.

Problem area and season — Other than December and January, the problem occurs during most of the year, mainly in Areas 1 and 2.

SQUID JIGGING

The jigging fishery involves jigs attached to handlines being operated from vessels to catch chokka squid *Loligo vulgaris reynaudii*. The jig is essentially a plastic lure with two rings of barbless hooks. The jigs are dropped to the sea bottom or close to it and then retrieved with a jerking movement.

Operational consumption — Negligible (Table I).

Operational gear damage — Negligible.

Operational disturbance — The occurrence of seals during squid fishing inshore on the South Coast has been put at less than 2 per cent, and seals may actually aid detection of squid shoals by their presence when feeding (W. H. H. Sauer, Port Elizabeth Museum, pers. comm.).

Problem area and season — The main fishing area for squid is between Plettenberg Bay and Port Alfred in Area 3, resulting in little overlap between the seal feeding distribution and that of the fishery.

MISCELLANEOUS NETTING

Miscellaneous nets include set-nets, drift nets and beach-seine nets, all of which are used inshore. Set or drift nets of different mesh sizes are used to catch mullet *Liza richardsoni* and St Joseph sharks *Callorhinchus capensis*, and are set and left for a few hours at a time before being pulled up and the fish removed. Beach-seine nets are used to catch mullet from shore.

Operational consumption — Seals take fish from the nets, often only taking the stomach portion and leaving the rest. At most, an average for the whole coastline is thought to be <1 per cent of the catch lost or 2–3 per cent in hardest-hit areas. Using a figure of 1 per cent in Equation 3, the quantity taken by seals (21 tons per year) is a negligible (0,003%) percentage of total seal consumption (Table I).

Operational gear damage — Seals are thought to be the major cause of damage to nets set to catch mullet. Nets cost approximately R560 each, including floats etc., and replacement of netting averages R200, or less if twine is used to repair torn sections (M. W. de Wet, Sea Fisheries Research Institute, pers. comm.). However, repairs are labour-intensive. In the fishery for St Joseph shark, the nets tend to be more extensively damaged because shark spines snag in the nets as they are pulled out by seals. Disturbance to the drift-net industry by seals has previously been recorded, but it was decided that, for conservation reasons, drift-nets should not be used (Anon. 1987). Seals may damage beach-seine nets too, but damage tends to be minimal.

Operational disturbance — Seals can chase fish from the nets, but if the fishermen stay with the net, they are less likely to suffer interference.

Problem area and season — The problem becomes worse at the end of the purse-seining season (towards the end of the year) in Areas 1 and 2, particularly near Lambert's Bay and Port Nolloth.

Summary of operational interactions affecting fisheries

All fisheries in South Africa report operational interactions with seals, but there is much variation in the strength of the interactions, and both temporal and spatial variability. The major area of interference is off the West Coast, where most fishing effort is concentrated.

CATCH LOST

Only in the demersal longline fishery (before it was stopped at the end of 1990) is consumption of catches notable at 5,3 per cent, followed by the handline fishery at 2,3 per cent. The percentage of catches from all important commercial fisheries that is taken by seals is estimated to be approximately 0,3 per cent (Table I), clearly a negligible figure. Other than this, there are environmental effects and other predators, such as sharks and dolphins, which cause losses during fishing operations. Longline skippers from the demersal and tuna fisheries comment on losses to sharks. There are also reports that dolphins take fish from trawl nets. Although dolphins with bullet wounds, thought to have been inflicted by fishermen, have been found, there appears to be little animosity towards them from fishermen.

When seals are consuming their daily ration of fish, whether it is taken from the fishing industry (which constitutes easier prey) or by means of free foraging, the effect on the resource is no different. However, two points should be noted. First, included in the calculations is the fact that seals often "play" with fish during fishing operations even when they are satiated, damaging the fish so that they cannot be utilized by the industry and leaving them uneaten, which wastes the resource. Second, seals may have access to fish, e.g. demersal kingklip, that normally they would not encounter during free foraging.

Operational consumption by seals is calculated as 0,3 per cent of total seal consumption (Table I), which is minimal. Claims that the fishing industry is supporting an artificially high seal population through seals taking advantage of fishing activities are therefore unfounded.

COST TO THE INDUSTRY

All interference by seals results in financial loss to the fishermen, some directly quantifiable and others hidden. In the latter category is the example of certain fishing techniques, particularly of a passive nature, which cannot be exploited because anticipated interference by seals renders the techniques non-feasible. The hidden social costs of this may be severe for small-scale fishermen, affecting the poorer, less-mechanized fishing communities. These costs are almost impossible to quantify, but the potential losses must be borne in mind.

Losses through operational consumption of catches have been estimated (see Table I), and translated into monetary units (Table II), where possible. The total loss is estimated at approximately R2,3 million from all fisheries because of seals, a small percentage (0,2%) in terms of the wholesale value of all fishery catches.

Operational gear damage does not seem to be a major problem other than during trawling, when seals damage propellers, and during handlining, when equipment is lost. It is also a problem, but less serious, when seals have to be cut loose from purse-seine nets, or when they remove or damage bait bags on rock-lobster hoopnets, break lines and hooks on tuna longlines, break squid jigs, and tear set-, drift- and beach-seine nets.

Somewhat less quantifiable than operational consumption and operational gear damage is operational disturbance resulting in both lost fishing time through delay caused by seals, such as when seals have to be removed from the vessel (trawl fishery) and through dispersal of fish shoals (purse-seine, handline, tuna poling and miscellaneous net fisheries), and in reduced catchability (handline and trap- and hoopnet fisheries).

Overall the costs to the fishing industry that can be quantified amount to approximately R3,4 million, but this is 0,3 per cent of the wholesale value of the catch. However, features of operational disturbance which are difficult to evaluate in monetary terms may well amount to a substantial financial loss in terms of vessel and manpower time.

Table II: Estimated financial losses from important commercial fisheries in South Africa during 1989 as a result of seal interference during fishing operations (see Table I and text for source of figures)

Fishery	Losses (R'000)				Wholesale value of catch (R'000)	Losses as a % of wholesale value of catch
	Operational consumption of catch	Operational damage	Operational disturbance	Total		
Trawl[1]	–	308	715	1 023 + ?	553 427	0,2 + ?
Purse-seine[1]	–	...	?	?	234 182	?
Demersal longline[2]	1 394[3]	–	–	1 394	24 975	5,6
Handline[2]	911[4]	42	?	953 + ?	38 632	2,5 + ?
Rock-lobster trap	...	...	...	...	81 650	...
Rock-lobster hoopnet	...	...	?	?	20 412	?
Tuna longline	...	...	–	...	13 056	...
Tuna poling	–	–	?	?	18 074	?
Squid jigging	...	...	–	...	88 128	...
Miscellaneous net[2]	39[5]	...	?	39 + ?	3 827	1,0 + ?
Total	2 344 + ...	350 + ...	715 + ?	3 499 + ?	1 076 366	0,3 + ?

1 Quota fisheries: although there is operational consumption from these fisheries, the loss is measured in fishing time, because a consequence of operational consumption is that more time will be needed to catch the lost mass
2 Non-quota fisheries: the financial value resulting from operational consumption is taken as the mass lost to seals (Table I) for these fisheries multiplied by the wholesale price (R per ton) of fish – [3] = R7 747, [4] = R3 097, [5] = R1 850
– No loss
... Negligible loss
? Unknown loss

Interactions detrimental to seals

There are a number of sources of mortality for seals directly related to fishing operations, namely entanglement in discarded fishing gear, drowning in fishing nets and deliberate killing by fishermen.

ENTANGLEMENT

Shaughnessy (1980) investigated the percentage of seals entangled in fishing debris from seal harvests at various colonies in the late 1970s and found that the incidence of entanglement was 0,1 per cent for immature seals. The value was, however, higher (0,6–0,7%) at Cape Cross, which is close to an important fishing ground. If an entanglement mortality of 0,1 per cent applies to all seals in South Africa, it could account for the deaths of 600 seals per year.

DROWNING

Drowning of seals occurs mostly in the trawl operation and seldom in purse-seining or in smaller set-, drift- and beach-seine nets. Calculations from the Shaughnessy and Payne (1979) data for bottom trawling show that one seal drowns in 5,6 per cent of trawls on the West Coast and in 1,8 per cent of trawls on the South Coast. Based on these figures and the number of trawls in the respective areas (19 464 and 30 274 on the West and South coasts respectively), an estimated 1 635 seals, or 0,27 per cent of the population in South Africa, drowned in trawl nets in 1989. However, the advent of the midwater trawl has resulted in a greater mortality of seals by drowning. On a research ship, 30 seals have been caught in a 20 minute midwater tow, and 16 seals have died in four commercial midwater trawls (BR unpublished data), i.e. four per trawl. Although there are only seven midwater trawlers active at present and these operate almost entirely on the South Coast, seal mortality could increase if the midwater trawl fishery expanded up the West Coast, where seals are more abundant.

DELIBERATE KILLING

Killing of seals without a permit is illegal (Section 3(b) of the Sea Birds and Seals Protection Act 46 of 1973). Enforcement of this law is the function of the Fisheries Control Officers (G. J. Kotzé *in litt.* to PAW, 23 May 1990), but this is a difficult task. The shooting or maiming of seals by fishermen is an ongoing illegal practice, and it occurs in all fisheries that have problems with seals. Generally, no action is taken against offenders because alternative methods of deterring seals from fishing operations are unavailable (Wiley 1986 and *in litt.* to N. Rice, 30 June 1983).

For decades there have been reports of large numbers of seals being shot each year by fishermen (Zur Strassen 1971, Anon. 1972, Laws 1973, Shaughnessy 1985, Crawford and Payne 1989). For instance, a purse-seine fisherman has been seen to fire 85 rounds at seals in and around his net (Anon. op. cit.). If all fishermen from the approximately 100 purse-seiners working during that time were shooting at that rate, then mortalities and woundings could have been significant. There are also reports of ammunition being sold to fishermen. For example, 45 000–60 000 rounds of ammunition per month were being sold to fishermen in Namibia (Anon. op. cit., Laws op. cit.). Many fishing vessels have firearms on board and use them either to kill seals or to frighten them away from a vessel, such as in the handline (Rand 1959) and longline (Japp 1989) fisheries. Harpoons and gaffs are also used on seals close to longliners (Japp op. cit.). Shaughnessy (1985) concluded from counts of seal carcases that there was a high mortality rate of seals along the coast of Namibia as a result of the purse-seine fishery.

TOTAL MORTALITY

The magnitude of mortalities inflicted on the seal population is unknown, but speculation can be made of the potential mortality in South African waters. If during 1989, for example, one seal was shot and killed at 10 per cent of all trawls (49 738), purse-seine hauls (11 864), longline sets (1 737) and handline fishing days (45 871), this could amount to a total of 10 921 seals being killed intentionally annually. Combining this with mortality from entanglement (600) and drownings at trawls (1 635) gives a total potential mortality of 13 156 seals as a direct result of fishing operations (2,2% of the seal population). This is equivalent to the average harvest of 13 683 seals in South Africa over the 10-year period 1980–1989 (Wickens *et al.* 1991).

Methods of deterring seals

A number of attempts have been made to find efficient and humane methods of deterring seals from fishing operations, but none has proved successful for all fisheries. Experiments in the early 1970s using explosive firecrackers, e.g. "Thunderflashes" and "Belugas", proved unsuccessful. A smaller version of the "Thunderflash", sold as a "Seal deterrent" (Shaughnessy *et al.* 1981) was used between 1973 and 1976, but while they seemed to work for the seals, they were also alleged to disturb the fish, and are generally no longer used (Anon. 1976). Electronic pulses and air guns had no lasting effects (Anon. 1977) and sounds of killer whales and of shots fired into the water (Anon. 1975a, b, 1978) were also unsuccessful. An arc-transducer producing compression and sound levels similar to those of firecrackers and shots fired into the water deterred seals from a trawlnet, but had no effect on seals at a purse-seine net and appeared less successful than the firecrackers (Shaughnessy *et al.* op. cit.). Another method tried was a "Seal Scram", an electronic unit used on the grey seal in the North Atlantic. It emits random underwater sound pulses at a frequency that deters phocid seals, but the unit had no effect on the South African fur seal (J. H. M. David, Sea Fisheries Research Institute, pers. comm.).

CONCLUSIONS

In an attempt to put the interactions between seals and commercial fisheries in South Africa into perspective, this paper has provided a synthesis of both the role of seals and fisheries as potential competitors, and of the conflicts between seals and fisheries.

As potential competitors, seals and fisheries are important predators and take equivalent quantities of fish. However, neither is the major consumer of important resources. However, if the fishing industry is considered to impact on fish stocks, the seal population presumably can have a similar influence. In particular, seals are important predators of one of the key pelagic resources, anchovy. Seal numbers are still increasing, which has led to concerns that fishery catches may decline as a result of seal predation. This, in turn, has led to calls for a reduction in the numbers of seals. As has been pointed out previously (David 1987), seals are conspicuous, and it is therefore probable that the role of seals as top predators has been overemphasized in comparison to that of other less-visible predators. There are few concerns that predatory fish may be competing for the harvested resource, perhaps because the fishing industry as a whole benefits from the yield of such fish. At present, the complexity of the biological interactions precludes both accurate predictions of the quantitative consequences for commercial fisheries of future increases in the seal population, and simple intuitive measures to solve the problem.

In an attempt to determine the operational conflicts which have real, financially detrimental effects on fisheries, this paper has provided a description of the interactions and preliminary calculations of the costs to all fisheries in South Africa. The first conclusion is that it is highly unlikely that the fishing industry is supporting an artificially high seal population through providing the seals with a free source of food. The second is that, overall, the fishing industry does not suffer a substantial financial loss as a result of seals, although the loss is possibly severe for particular fisheries in localized areas and at certain times of year. It is the more severe operational incidents that remain clearly in the minds of those affected, so that qualitatively there is still a problem.

Not provided here is a full assessment of damaged equipment, time wasted or additional manpower required resulting from seal interference. Neither is there an evaluation of these losses as compared to losses from other sources (such as handline gear damaged as a result of shark attack, bottom snagging or poor angling techniques). Only once this is done can the seal/fisheries operational conflicts be quantified properly. Further investigation of these losses is now being carried out and should provide better insight into some of the "unknowns" described in this paper.

Although, on average, it appears that operational interactions are of little real cost to fisheries, they may cause a potentially significant mortality to the seal population, and this mortality, as a direct result of fishing operations through entanglement, drowning and killing, is of an order of magnitude that requires monitoring. A solution to alleviate financial losses attributable to seals during operational interactions is unlikely to be generalized culling, unless this were of enormous magnitude, which is neither a practical nor feasible solution for incidences which are not of a large scale overall, and are often caused by a few rogue seals. Practical operational solutions (such as adaptation of boats or the use of deterrents) are required when and where interactions occur. Some members of the fishing industry feel that empowering fishermen to act against raiding seals, thereby enabling them to protect themselves from interference during fishing operations, would be sufficient to diffuse all grievances against seals. However, the effects of allowing fishermen to act as they wish must first be established. Allowing fishermen to shoot seals as a solution to interactions has the disadvantage in that removals alter seal numbers and age structure. Unless there is some control over the size/age and number taken, monitoring of the population becomes difficult. Certainly, the discovery of an effective deterrent to keep seals from fishing operations is likely to alleviate both the problems for fishermen (whether perceived or real) and the unknown number of deaths which can cause problems for population monitoring and, therefore, management of the seal population.

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